Application of a physically-based interpolation method to reconstruct an aquifer boundary produced by a preserved paleotopography

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Abstract. Accurate simulation of groundwater systems requires reliable determination of aquifer boundaries. For boundaries produced by paleotopography, distinctive features, such as incised valleys and parabolic hillslopes, may provide evidence for the processes that shaped the surface and assist boundary reconstruction. The Cerro Toledo Interval is the informal name for the uppermost geologic layer capable of perching groundwater underneath the Los Alamos National Laboratory (LANL). The upper boundary of the Cerro Toledo Interval is a paleotopography that was exposed to hillslope and fluvial processes for approximately 400 ka before it was preserved by a subsequent ash-flow eruption that emplaced the overlying Tshirege Member of the Bandelier Tuff. Drainage patterns preserved in the upper boundary of the Cerro Toledo Interval may be an important factor in determining groundwater flow and contaminant transport in the area. The shape of this boundary must be determined by interpolating a limited number of point elevation values acquired from well logs and exposed contacts. Unfortunately, the most commonly-used interpolation techniques are not appropriate for recreating such a surface because they produce smooth surfaces that do not exhibit drainage patterns. In this work, we present a generalization of a physically-based interpolation technique that was originally designed for fluvially-eroded topography, and we describe its application to the paleotopography underlying LANL. The original method is generalized for use on interpolation regions that do not necessarily contain complete drainage basins. Also, the method is applied in a stochastic framework that estimates the probability that any point in the interpolation region drains toward a specified boundary. Simulations with the generalized method produce draining surfaces with three to four major drainages, which is consistent with previous findings based on field studies. In addition, although the reconstructed paleotopography varies between simulations, large areas of the interpolation region are consistently routed toward particular boundaries, which may give some indications of directions groundwater flow and potential contaminant transport.

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